EEU44C04 / CS4031 / CS7NS3 / EEP55C27
Next Generation Networks

Overview of wireless networks

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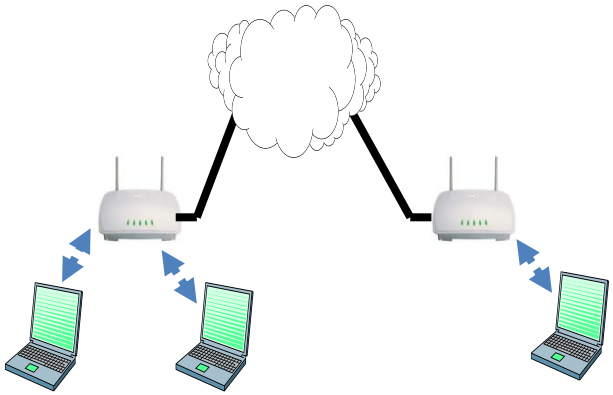
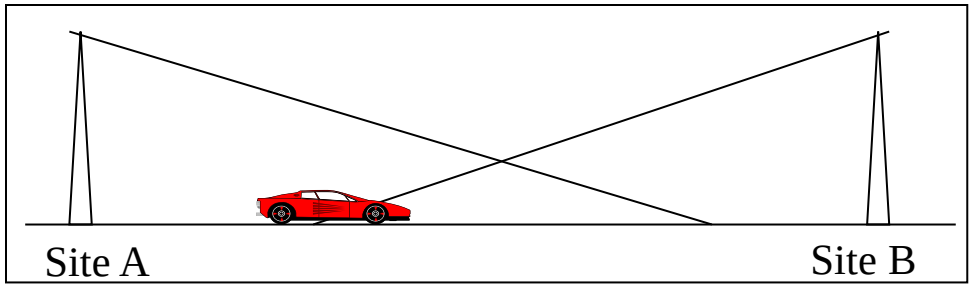
Types of wireless networks



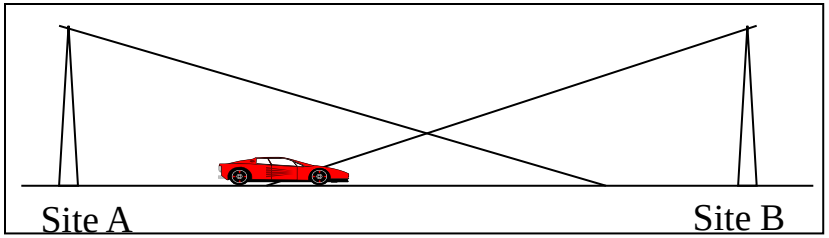
Nomadic



Mobile

Mobile

- Seamless roaming
- Wireless telephony
- Mobile data services
  - ✓ Email, web browsing, short message service (SMS), videos, social content
- Vehicular ad hoc networks
- Location-aware services

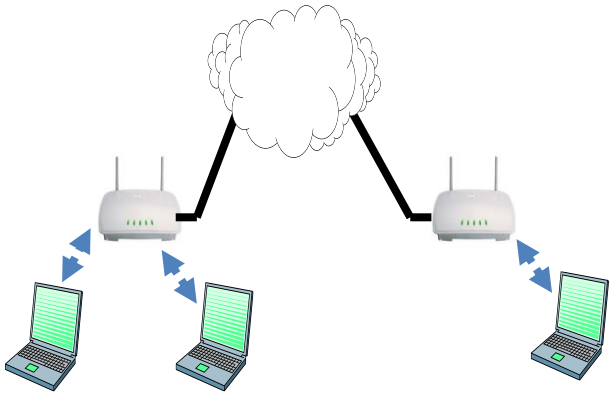


Technologies:

- Cellular/PCS (GSM, GPRS, UMTS, LTE, 5G, B5G/6G, etc.)
- IEEE 802.16
- Land mobile radio
- Satellite

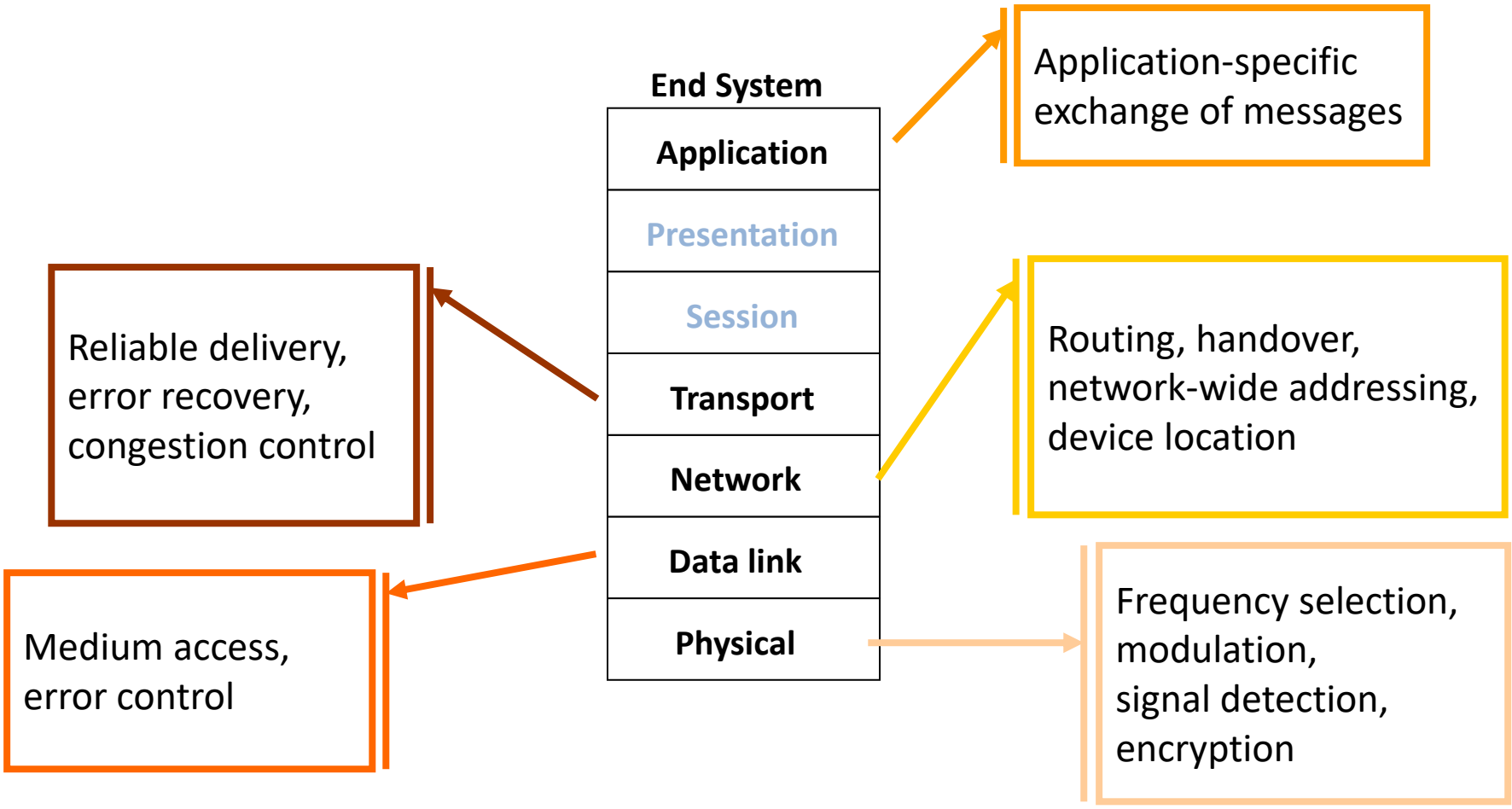
Nomadic

- User changes point of connection to the network
  - ✓ Seamless roaming not necessary
- Wireless local area networks (WLAN)
- Hot spots
- Wireless ISPs



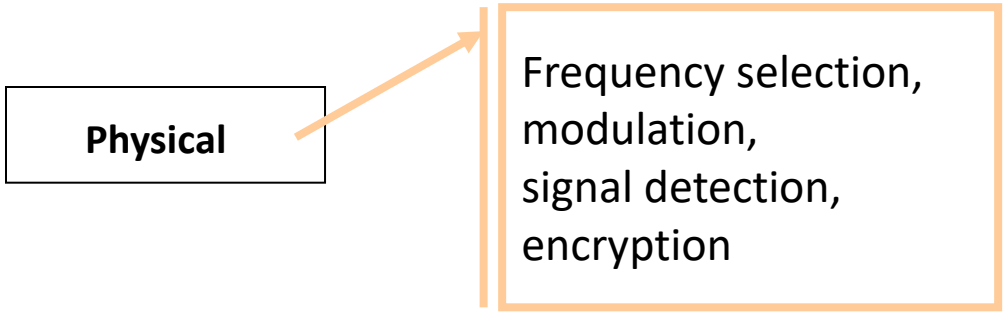
Technologies:
- IEEE 802.11
- Bluetooth

OSI reference model



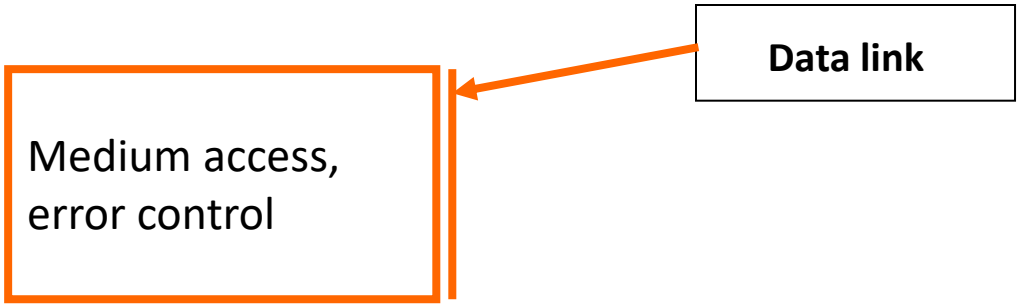
Physical layer (PHY)

- Handles **communications impairments** (noise, interference, fading, shadowing, path loss, etc.) through coding, diversity, power control, waveform selection, etc.
- Responsible for modulation, frequency selection, signal detection
- Encryption



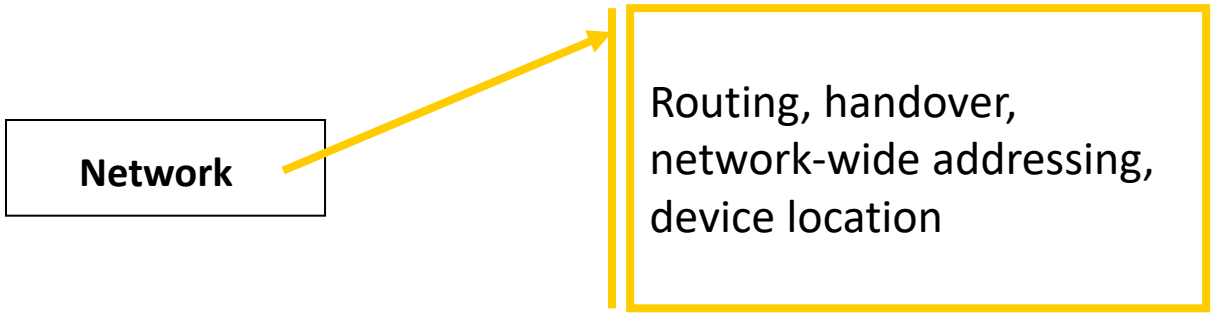
Data link layer

- Responsible for **mediating access** to the wireless medium
- Frame synchronization
- Reliable point-to-point or point-to-multipoint connection



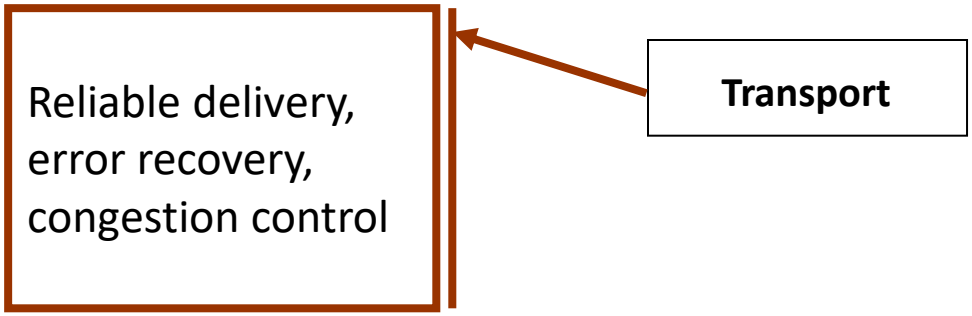
Network layer

- **Network-wide** addressing, and redirection to deal with mobility
- Handoff (handover) between different networks
- Routing through multiple hops in ad-hoc networks



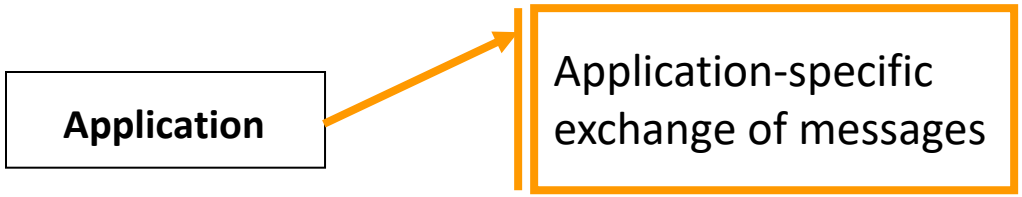
Transport layer

- Reliable **end-to-end** transmission
- Flow and congestion control

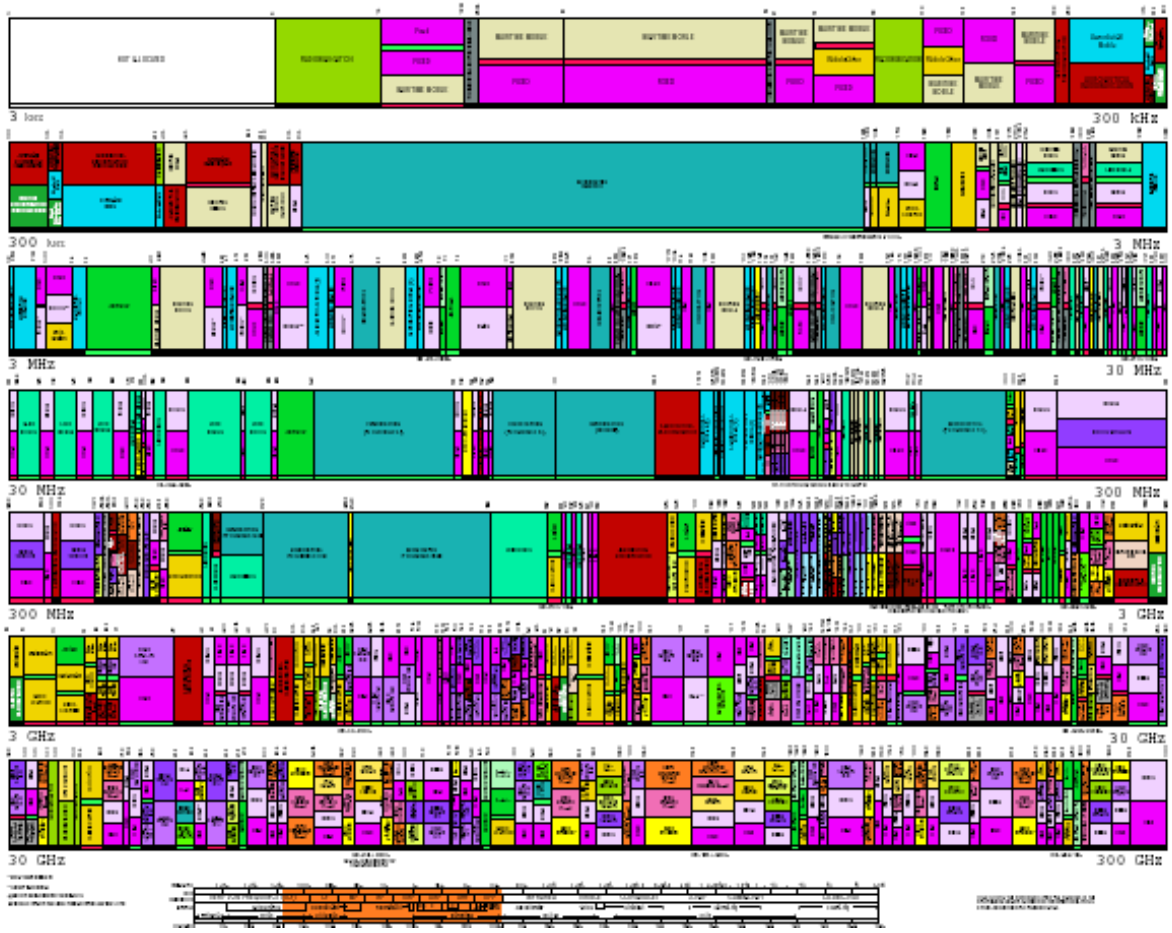


Application layer

- Application layer protocols may need to be tuned to support the constraints of **mobile devices** (small screen, low power, …)
- Wireless Application Protocol (WAP)
- Location-aware services
- Wireless web access



United States frequency allocations



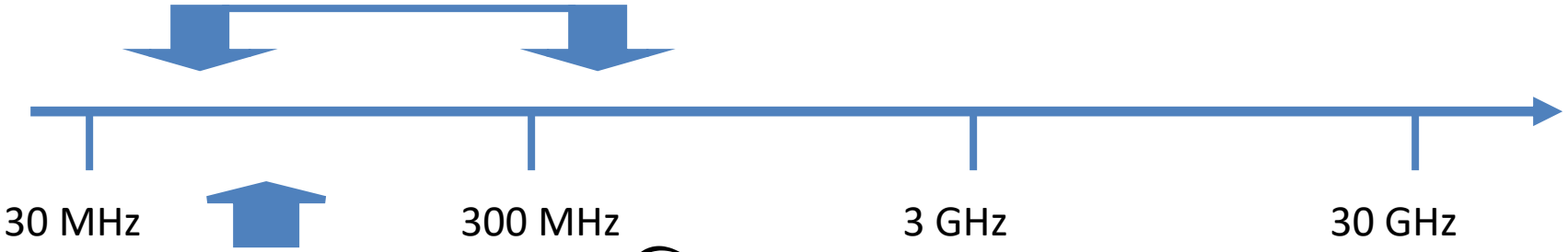
Is it tidy?

And btw, what's with the number 3? (3 KHz, 3 MHz etc.)

Broadcast radio and TV

Broadcast TV

- VHF: 54 to 88 MHz, 174 to 216 MHz
- UHF: 470 to 806 MHz



FM Radio

- 88 to 108 MHz

Digital TV

- 54 to 88 MHz, 174 to 216 MHz, 470 to 806 MHz

Cellular and PCS

3G Broadband Wireless
- 746-794 MHz, 1.7-1.85 GHz, 2.5-2.7 GHz

4G
- 800 MHz, 1.8 GHz

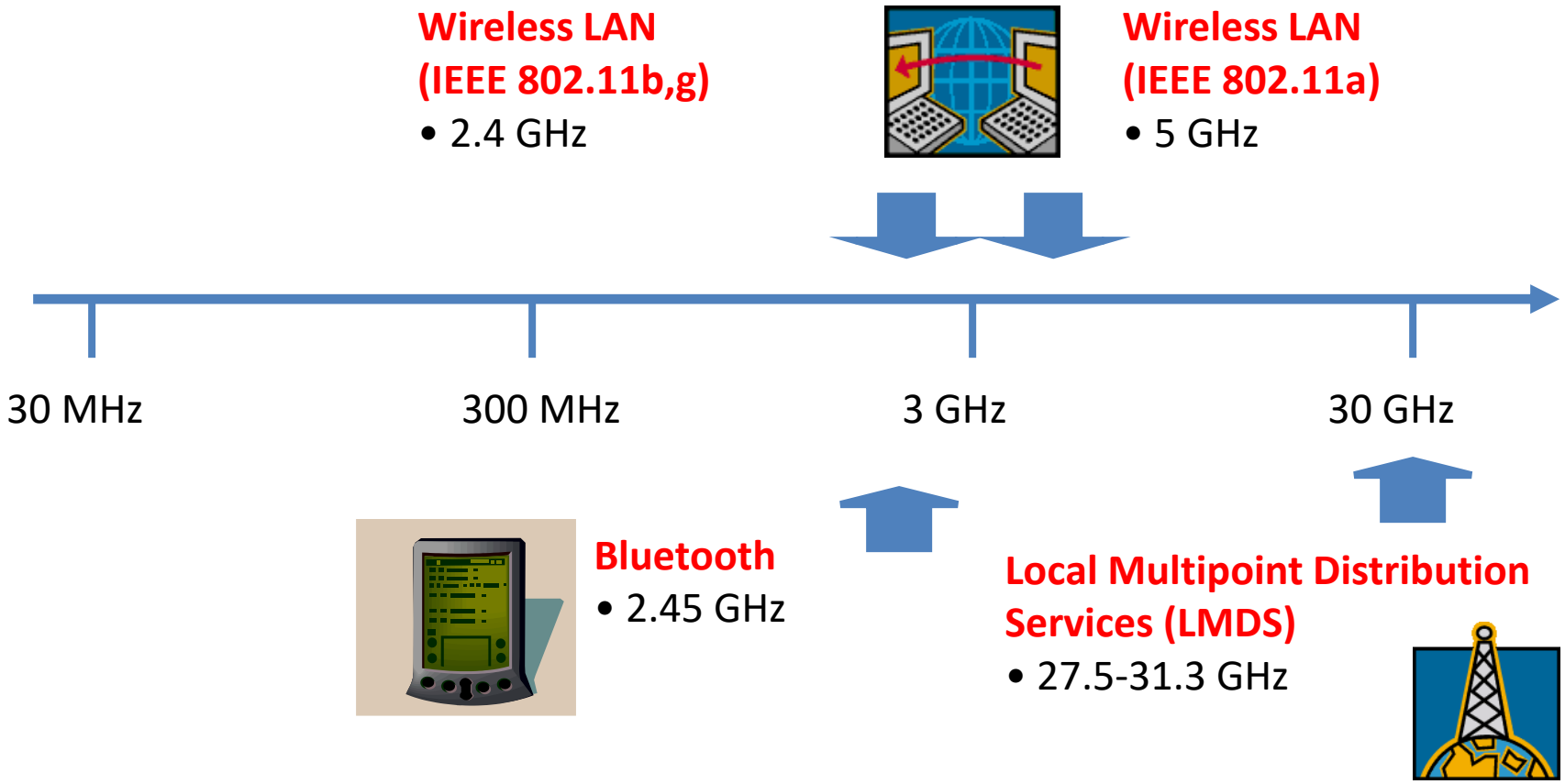
30 MHz | 300 MHz | 3 GHz | 30 GHz

5G
- 3.4-3.8 GHz

2G Cellular Phone
- 800-900 MHz

Personal Communication Service (PCS)
- 1.85-1.99 GHz

WLANs, WPANs, fixed wireless

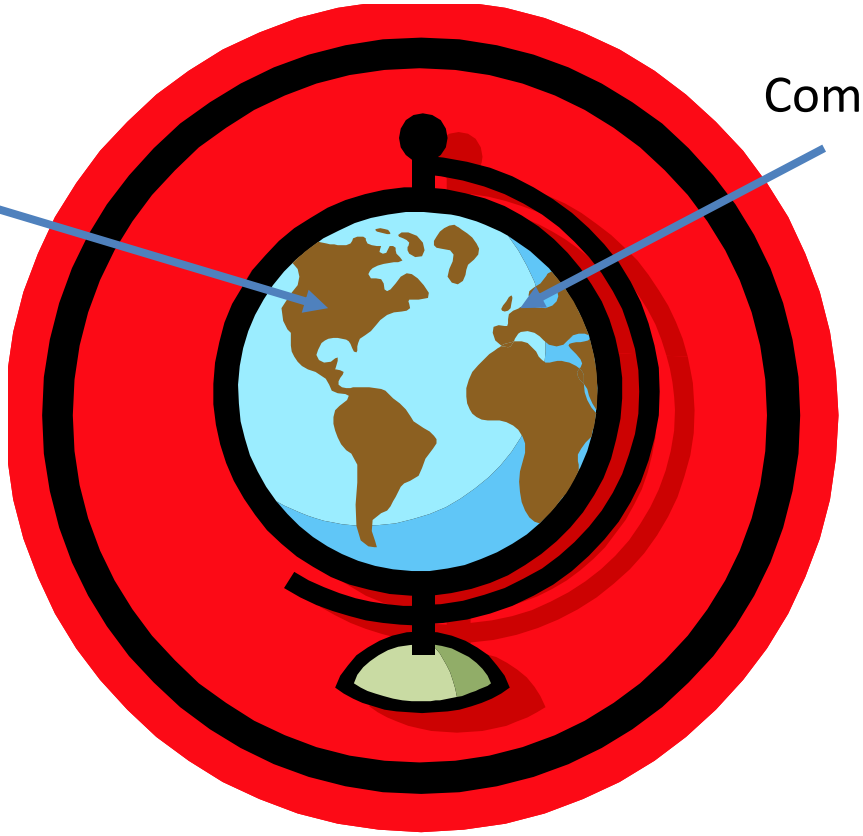


Regulators

International Telecommunications Union – Radiocommunication sector (ITU-R) handles **standardization and frequency planning**

Federal Communications Commission (USA)

ComReg (Ireland)



ComReg = Commission for Communications Regulation

Harmonization

- Some degree of harmonization (more rational/efficient re-organization) of spectrum utilization world-wide is desirable
  - ✓ Not easy: a lot of legacy systems (see former slide on US frequency allocations)
  - ✓ But necessary, both for interference avoidance (inter-operability) and for economic reasons (economies of scale)
  - ✓ ITU-R periodically holds the **World Radio Conference**, where the allocation of the spectrum to different services is decided

Dynamic spectrum access

- Spectrum is not used very efficiently
  - ✓ But it is very difficult to take spectrum back from those licensed to operate in a given band
  - ✓ Counterexample: Spectrum re-farming of TV bands due to efficiencies in the switch to digital TV
  - ✓ **Dynamic spectrum access:** allows operation in licensed bands, as long as you don't interfere with holder of the license
    - ➢ Cognitive radio networks attempting to make this a reality

Which of the following regions of the spectrum is best suited and in fact used for TV transmission?

- ❑ < 1GHz
- ❑ Between 1GHz and 5GHz
- ❑ >5GHz

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Transmissions at lower frequencies attenuate less with distance, which makes these bands ideal for long range transmissions, such as TV ones.

Comment on the complementarity of wired and wireless systems.

- **Wireless and optical wireless networks can be thought of as complementary.**

- **Optical fibre does not reach everywhere, but where it does reach, it provides a very large amount of bandwidth.**

- **Wireless access networks, on the other hand, potentially reach almost everywhere, but provide a highly bandwidth-constrained transmission channel, susceptible to a variety of impairments.**

Given that the user in a certain mobile communication system, is moving with a velocity of 1,000 km/h, which of the following downlink power allocation strategies makes more sense, assuming multiple antennas at the base station?

(i) The transmit power budget is divided evenly among the base station's antennas.

(ii) The transmit power budget is divided among the base station's antennas, according to the channel state information feedback provided by the mobile phone to the base station.

(iii) No transmit power is assigned to the user if it experiences a bad channel condition.

(i) **The transmit power budget is divided evenly among the base station's antennas.**

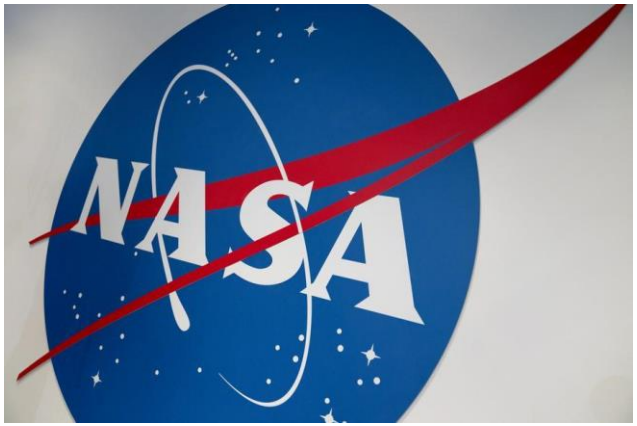
➔**no up-to-date channel state information can be fed back to the transmitter if users are moving very fast, as channel coherence time is shorter than feedback+transmission time.**

Given an OFDM transmission link in outer space, which of the following feedback schemes is the most efficient choice to provide channel state information to the transmitter?

(i) The channel quality is reported for every subcarrier.

(ii) The channel quality is reported for subchannels of N_s subcarriers, where N_s is greater than one and smaller than the maximum allowed number of subcarriers.

(iii) The channel quality is reported only once, averaging it out over all the system bandwidth.



(iii) **The channel quality is reported only once, averaging it out over all the system bandwidth.**

➔in outer space there is no multipath (no scatterers) which means no frequency selectivity, therefore channel will have the same gain over all the bandwidth.